(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 0 709 112 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.05.1996 Bulletin 1996/18

(51) Int. Cl.[6]: **A61N 1/365**, A61N 1/368

(21) Application number: **95250247.4**

(22) Date of filing: **10.10.1995**

(84) Designated Contracting States:
BE CH DE FR IT LI NL SE

(30) Priority: **31.10.1994 US 331898**

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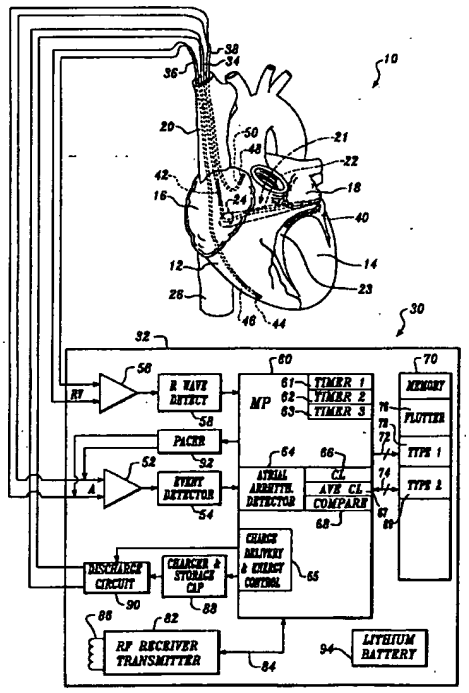
(54) Atrial fibrillation type selective cardiovertor

(57) An atrial cardiovertor/defibrillator (30) provides therapy to the atria corresponding to the type of atrial arrhythmia occurring in the atria of the heart. The atrial cardiovertor/defibrillator includes a memory (70) for storing respective different criteria for each of different types of atrial arrhythmia, a sensor (52) for sensing activity of at least one of the atria of the heart to provide an electrogram signal, and a cardiovertor (90) for providing a corresponding therapy to the heart for each of the different types of atrial arrhythmia. The cardiovertor/defibrillator further includes an atrial arrhythmia detector (64) responsive to the electrogram signal and the stored criteria for identifying one of the types of atrial arrhythmia to cause the cardiovertor to provide therapy to the heart corresponding to the identified atrial arrhythmia.



EP 0 709 112 A2

Description

BACKGROUND OF THE INVENTION

The present invention generally relates to an atrial cardiovertor/defibrillator for applying cardioverting electrical energy to the atria of a human heart in need of cardioversion. The present invention is more particularly directed to an improved atrial cardiovertor/defibrillator which provides cardioversion therapy corresponding to the relative degree of organization/disorganization of a detected atrial arrhythmia.

Atrial fibrillation is probably the most common cardiac arrhythmia. Although it is not usually a life-threatening arrhythmia, it is associated with strokes thought to be caused by blood clots forming in areas of stagnant blood flow as a result of prolonged atrial fibrillation. In addition, patients afflicted with atrial fibrillation generally experience palpitations of the heart and may even experience dizziness as a result of reduced cardiac output.

Atrial fibrillation occurs suddenly, and many times can only be corrected by an external defibrillator discharging electrical energy to the heart through the skin of the patient. This treatment is commonly referred to as synchronized cardioversion and, as its name implies, involves applying electrical defibrillating energy to the heart in synchronism with a detected R wave of the heart. The treatment is very painful and, unfortunately, most often provides patients only with temporary relief lasting but a few weeks to months.

Drugs are available for reducing the incidence of atrial fibrillation. However, these drugs have many side effects and many patients are resistant to them, which greatly reduces their therapeutic effect.

Implantable atrial defibrillators have been proposed to provide patients suffering from occurrences of atrial fibrillation with relief.

Such known atrial defibrillators either do not provide atrial fibrillation detection or detect for the simple presence or absence of atrial fibrillation. All such atrial defibrillators provide only a single therapy regimen.

It has been observed that atrial activity associated with atrial arrhythmias can vary in organization from highly organized activity to highly disorganized activity. Atrial flutter, for example, is a highly organized atrial arrhythmia. Atrial activity of increasing disorganization, beyond atrial flutter, is generally referred to as atrial fibrillation. Atrial arrhythmias, therefore, encompass a wide range of organization and disorganization from atrial flutter, which is highly organized, to atrial fibrillation, which itself encompasses a wide range of atrial activity organizational characteristics, from what may be referred to as atrial activity of intermediate organization to atrial activity of high disorganization. Recognizing these atrial arrhythmia characteristics, Wells, Jr. et al. in *Characterization of trial Fibrillation in Man: Studies Following Open Heart Surgery*, Pace, Vol. 1, pp. 426-438, Oct-Dec, 1978, type characterized various forms of atrial fibrillation and further reported that the atria, during an arrhythmic episode, can transition between the characterized forms of atrial arrhythmias and can even self-revert to normal sinus rhythm. In addition to the above, it has been more recently learned through research sponsored by the assignee of the present invention that the amount of cardioverting electrical energy required to cardiovert an atrial arrhythmia to return the atria to a normal rhythm increases as the degree of disorganization in atrial activity increases during an arrhythmic episode.

While atrial defibrillators which detect the simple presence and absence of atrial fibrillation (including atrial flutter) and which provide a single intervention regimen if atrial fibrillation is detected will provide needed relief for many patients, these devices for some patients exhibit certain deficiencies. For example, the single intervention regimen can result in a greater amount of electrical energy being applied to the atria than needed to successfully cardiovert the atria. This can submit the patient to a higher degree of potential discomfort than would otherwise be necessary. It can also result in a greater than necessary consumption of battery power which would ultimately shorten the useful life of the cardioverting device. As another example, and at the other end of the organization spectrum, the atrial activity may be so disorganized that the implanted defibrillator is incapable of providing a sufficient amount of energy to cardiovert the atria. Where a single intervention regimen is utilized, therefore, cardioversion would still be attempted with a quantity of cardioverting energy which is less than that required to cardiovert the atria. This would also submit the patient to therapy destined to be ineffective and, hence, therapy which should not be applied, while wasting precious battery power.

SUMMARY OF THE INVENTION

The present invention therefore provides an atrial cardiovertor/defibrillator including criteria establishing means for providing a respective different criteria for each of different types of atrial arrhythmia, a sensor for sensing activity of at least one of the atria of a heart to provide an electrogram signal, and therapy means for providing a corresponding therapy to the heart for each of the different types of atrial arrhythmia. The atrial cardiovertor/defibrillator further includes classifying means responsive to the electrogram signal and the criteria establishing means for identifying one of the types of atrial arrhythmia and causing the therapy means to provide the therapy to the heart corresponding to the identified one of the types of atrial arrhythmia.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic block diagram of a fully implantable atrial cardiovertor/defibrillator embodying the present invention, shown in association with a human heart in need of atrial arrhythmia monitoring and potential cardioversion.

Figure 2 is a flow diagram illustrating the manner in which the atrial cardiovertor/defibrillator of Figure 1 may be implemented to identify atrial arrhythmia type and provide corresponding cardioversion therapy.

Figure 3 is a flow diagram illustrating the manner in which the atrial cardiovertor/defibrillator of Figure 1 may be implemented to provide intervention therapy for atrial fibrillation of high disorganization.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Figure 1, it illustrates a fully implantable atrial cardiovertor/defibrillator 30 embodying the present invention shown in association with a schematically illustrated human heart 10 in need of atrial arrhythmia monitoring and potential cardioversion. The portions of the heart 10 illustrated in the Figure 1 are the right ventricle 12, the left ventricle 14, the right atrium 16, the left atrium 18, the superior vena cava 20, the coronary sinus channel 21 which, as used herein, denotes the coronary sinus 22 and the great cardiac vein 23, the coronary sinus ostium or opening 24, and the inferior vena cava 26.

The atrial cardiovertor/defibrillator 30 generally includes an enclosure 32 for hermetically sealing the internal circuit elements of the atrial cardiovertor/defibrillator, to be described hereinafter, an intravascular lead 34, a first endocardial lead 36, and a second endocardial lead 38. The enclosure 32 and the leads 34, 36 and 38 are arranged to be implanted beneath the skin of a patient so as to render the atrial cardiovertor/ defibrillator 30 fully implantable.

The intravascular lead 34 generally includes a first or tip elongated electrode 40, and a second or proximal elongated electrode 42. As illustrated, the lead 34 is flexible and arranged to be passed down the superior vena cava 20, into the right atrium 16, into the coronary sinus ostium 24, and advanced into the coronary sinus channel 21 of the heart near the left side thereof, so that the electrode 40 is within the coronary sinus channel 21 either within the coronary sinus 22 adjacent the left ventricle 14 and beneath the left atrium 18, or most preferably within the great cardiac vein 23 beneath the left atrium 18. The electrodes 40 and 42 are spaced apart such that when the first electrode 40 is positioned as described above, the second electrode 42 is in the right atrium 16. The first electrode 40 together with the second electrode 42 provide for the delivery of cardioverting/defibrillating electrical energy to the atria, in a manner to be described subsequently.

The first endocardial lead 36 preferably includes a bi-polar pair of electrodes 44 and 46, arranged for establishing electrical contact with the right ventricle 12 of the heart 10. The electrodes 44 and 46 permit bi-polar sensing of ventricular activations (R waves) in the right ventricle. As illustrated, the lead 36 is fed through the superior vena cava 20, into the right atrium 16, and then into the right ventricle 22.

The second endocardial lead 38 also preferably includes a bi-polar pair of electrodes 48 and 50, arranged for establishing electrical contact with the right atrium 16 of the heart 10. The electrodes 48 and 50 are closely spaced apart for sensing localized activity of the right atrium. As illustrated, the lead 38 is fed through the superior vena cava 20, into the right atrium 16. The distal end of the lead 38 is substantially "J" shaped in a manner know in the art to position electrodes 48 and 50 in the appendage of the right atrium.

Within the enclosure 32, the atrial cardiovertor/defibrillator 30 includes a first sense amplifier 52, an atrial event detector 54, a second sense amplifier 56, and an R wave detector 58. The first sense amplifier 52 forms a first sensing means which, together with the electrodes 48 and 50 of the second endocardial lead 38 to which sense amplifier 52 is coupled, senses localized activity of the right atrium 16 to provide an electrogram signal to the atrial event detector 54. The second sense amplifier 56 forms a second sensing means which, together with electrodes 44 and 46 of the first endocardial lead 36 to which it is coupled, senses cardiac activity in the right ventricle of the heart to provide a second electrogram signal to the R wave detector 58.

The R wave detector 58 preferably includes a differentiating filter for differentiating the electrogram signal provided by sense amplifier 56. The R wave detector 58 further preferably includes a threshold circuit for setting an upper and lower threshold to provide an output when the upper or lower threshold is exceeded. The thresholds are set, as known in the art, so that only R waves will have sufficient amplitude to exceed the thresholds of the R wave detector.

The atrial event detector 54 similarly preferably includes a differentiating filter for differentiating the first electrogram signal, and a threshold circuit for setting an upper and lower threshold. When the differentiated first electrogram signal transitions beyond either the upper or lower threshold, the atrial event detector 54 provides an output indicating the occurrence of an atrial event.

The enclosure 32 of the atrial cardiovertor/defibrillator 30 further includes a microprocessor 60. The microprocessor 60 is preferably implemented in accordance with this embodiment of the present invention to result in a plurality of functional stages. The stages include a first timer 61, a second timer 62, and a third timer 63. The stages further include an atrial arrhythmia detector 64 and a charge delivery and energy control stage 65. The atrial arrhythmia detector 64 includes an atrial cycle length determining stage 66, an average cycle length determining stage 67, and a compare stage 68.

The microprocessor 60 is arranged to operate in conjunction with a memory 70 which is coupled to the microprocessor 60 by a multiple-bit address bus 72, and a bi-directional multiple-bit data bus 74. This permits the microprocessor 60 to address desired memory locations within the memory for executing write or read operations. During a write operation, the microprocessor stores data, such as atrial cycle lengths, or operating parame-

ters, such as atrial arrhythmia type classifying criteria, in the memory at the addresses defined by multiple-bit addresses conveyed over the address bus 72, and conveys the operating parameters and data to the memory 70 over the multiple-bit data bus 74. During a read operation, the microprocessor 60 obtains data or operating parameters from the memory at the storage locations identified by the multiple-bit addresses provided over the address bus 72 and receives the operating parameters and data from the memory over the bi-directional data bus 74.

For entering programmable operating parameters into the memory 70, as for example, cardioverting or defibrillating peak voltages, or further, for example, atrial arrhythmia type classification criteria into memory portions 76, 78 and 80, the microprocessor 60 receives the programmable operating parameters from an external controller (not shown) which is external to the skin of the patient. The external controller may be arranged to communicate with a receiver/transmitter 82 within enclosure 32 which is coupled to the microprocessor 60 over a bi-directional bus 84. The receiver/transmitter 82 receives the programmable parameters from the external controller and then conveys the same to the microprocessor 60 for storage in memory 70. The receiver/ transmitter 82 also conveys various information which it obtains from the microprocessor over bus 84 to the external controller.

The receiver/transmitter 82 includes a transmitting coil 86 so that the receiver/transmitter 82 and coil 86, together with the external controller, form a communication system. Such communication systems are well known in the art. One preferred communication system is disclosed in U.S. Patent No. 5,342,408, which issued on August 30, 1994, for "TELEMETRY SYSTEM FOR AN IMPLANTABLE CARDIAC DEVICE", which patent is assigned to the assignee of the present invention and incorporated herein by reference.

To complete the identification of the various structural elements within the enclosure 32, the atrial cardiovertor/defibrillator 30 further includes a charger and storage capacitor circuit 88 of the type well known in the art which charges a storage capacitor to a selected peak voltage, and a discharge circuit 90 for discharging the storage capacitor within circuit 88 for a predetermined time to provide a controlled discharge output of electrical energy to the atria of the heart when required. To that end, the discharge circuit 90 is coupled to electrodes 40 and 42 of the intravascular lead 34 for applying the cardioverting or defibrillating electrical energy to the atria. Lastly, the cardiovertor/defibrillator 30 includes a pacer 92 and a depletable power source 94, such as a lithium battery, for providing power to the electrical components of the atrial cardiovertor/defibrillator 30. The pacer 92 is coupled to the electrodes 48 and 50 to provide overdrive pacing of the atria, in a manner to be described hereinafter, when atrial flutter of the atria is detected.

Atrial arrhythmia type classification criteria are established in the memory 70 and more particularly in memory portions 76, 78 and 80. Memory portion 76 stores criteria for atrial flutter which is highly organized. Memory portion 78 stores criteria corresponding to atrial fibrillation of intermediate organization (type 1), and memory portion 80 stores criteria corresponding to atrial fibrillation of high disorganization (type 2). The degree of organization or disorganization can be determined by atrial cardiac cycle length alone, or in combination with a measure of atrial cardiac cycle length variability.

At predetermined times, determined by the first timer 61, the atrial arrhythmia detector 64 is activated to determine if an atrial arrhythmic episode is occurring in the atria, and to classify the arrhythmia if one is present. The atrial cycle length determining stage 66 determines, over a predetermined time or over a predetermined number of atrial cardiac cycles, the atrial cardiac cycle lengths of the heart, and stores the cycle lengths in memory 70. The atrial cardiac cycle lengths are the time spans between adjacent atrial events as identified by the atrial event detector 54. Once the cycle lengths are determined, an average cycle length is determined by the average cycle length determining stage 67. The average cycle length is then compared by the compare stage 68 to the atrial arrhythmia type classification criteria stored in memory portions 76, 78 and 80.

First, the microprocessor 60 accesses normal sinus rhythm criteria stored in memory 70 to determine if the atria are in normal sinus rhythm. More specifically, if the average cycle length is greater than a stored criteria of 250 milliseconds, for example, the atria are considered to be in normal sinus rhythm and, hence, an absence of atrial arrhythmia is considered to have been detected. If the atria are not in normal sinus rhythm and, hence, experiencing an arrhythmic episode, the type of atrial arrhythmia is then determined.

To determine the atrial arrhythmia type, the microprocessor 60 first accesses the memory portion 76 which establishes atrial flutter criteria. If the average atrial cardiac cycle length is less than 250 milliseconds, but greater than the 150 millisecond criteria stored in memory portion 76, the atria are considered to be in atrial flutter. A therapy corresponding to the detected atrial flutter is then applied to the atria, either by overdrive pacing or low energy cardioversion.

If the overdrive pacing therapy is selected by programming, the pacer 92 is activated by the atrial arrhythmia detector 64 to overdrive pace the atria in a manner well known in the art. The pacing pulses, to that end, are applied to the right atrium by electrodes 48 and 50.

If the low energy cardioversion therapy is selected by programming, the charge delivery and control stage 65 is activated by the atrial arrhythmia detector 64 to cause the capacitor of circuit 88 to be charged to a relatively low peak voltage of, for example, 80 volts. When the capacitor is charged, the charge delivery and energy control causes the discharge circuit 90 to discharge the capacitor of circuit 88 in timed relation to an R wave detected by sense amplifier 56 and R wave detector 58. The discharge circuit 90 discharges the capacitor of circuit 88 for a controlled period of time to provide the appli-

cation of cardioverting energy to the atria across electrodes 40 and 42 of lead 34. By charging the capacitor to a voltage of 80 volts, low cardioverting energy in the range of .2 joule is applied to the atria for cardioverting the atrial flutter.

If the atria are not in atrial flutter, the microprocessor 60 then accesses the memory portion 78 which establishes a criteria for atrial fibrillation of intermediate organization. If the compare stage 68 determines that the average atrial cardiac cycle length is less than 150 milliseconds, but greater than 75 milliseconds, the atria are considered to be in atrial fibrillation of intermediate organization (type 1). A therapy corresponding to the type 1 atrial fibrillation is then applied to the atria. In accordance with this preferred embodiment, the therapy applied to the atria corresponding to the type 1 atrial fibrillation is atrial cardioversion or defibrillation of an intermediate energy range of between .5 joules and 2 joules. To apply this therapy, the capacitor of circuit 88 is charged as previously described, and the charge delivery and energy control 65 causes the discharge circuit 90 to discharge the capacitor in timed relation to a sensed R wave, as previously described.

If the atria are not in type 1 atrial fibrillation, the microprocessor 60 may then access memory portion 80 to enable the compare stage 68 to determine if the average atrial cardiac cycle length satisfies the criteria for type 2 atrial fibrillation. To satisfy this criteria, in accordance with this embodiment, the average atrial cardiac cycle length must be less than 75 milliseconds. If it is, the atrial fibrillation is considered to be highly disorganized and a further and different therapy regimen than that previously described will be invoked. This therapy regimen will be described in detail hereinafter with respect to the flow diagram of Figure 3. As will be seen hereinafter with respect to the preferred embodiment of Figure 2, this last compare may be eliminated. However, it is included here for completeness because confirmation of the type 2 atrial fibrillation may be desirable before invoking the therapy of Figure 3.

Referring now to Figure 2, it illustrates, in flow diagram form, the manner in which the atrial cardiovertor/defibrillator 30 of Figure 1 may be implemented to identify an atrial arrhythmia type and provide corresponding cardioversion or defibrillation therapy. The process begins in step 100 wherein the first timer 61 is re-set and started. When it is determined in step 102 that the first timer 61 has timed out, the first timer 61 activates the atrial arrhythmia detector 64 in step 104.

Once the atrial arrhythmia detector is activated, the atrial arrhythmia detector 64 first determines if the atria are experiencing an arrhythmic episode in accordance with step 106. As previously described, if the average atrial cardiac cycle length is greater than 250 milliseconds, the atria will be considered to be in normal sinus rhythm, whereupon the process returns to step 100 to re-set and start the first timer 61. However, if the average atrial cardiac cycle length is less than 250 milliseconds, the process then proceeds to step 108, wherein it is determined if the atria are in atrial flutter. As previously described, if the atrial cardiac cycle length is greater than 150 milliseconds and less than 250 milliseconds, the atria will be considered to be in atrial flutter. As a result, in step 110, therapy is applied by either overdrive pacing or low energy cardioversion of the atria.

If it is determined in step 108 that the atria are not in atrial flutter, the process then proceeds to step 112 to determine if the atria are in type 1 atrial fibrillation. As previously described, if the average atrial cardiac cycle length is greater than 75 milliseconds, and less than 150 milliseconds, the atria will be considered to be in type 1 atrial fibrillation, which is atrial fibrillation of intermediate organization. If such a determination is made, the process then proceeds to step 114 to provide therapy corresponding to the type 1 atrial fibrillation, as previously described, by applying cardioverting or defibrillating electrical energy to the atria having an intermediate energy of between .5 joules and 2 joules, for example.

If the atria are not in atrial flutter, or in type 1 atrial fibrillation, it is then assumed that the atria are in type 2 atrial fibrillation. The process then, in accordance with step 116, proceeds to the therapy illustrated in Figure 3

Referring now to Figure 3, it illustrates in flow diagram form the manner in which the atrial cardiovertor/defibrillator 30 of Figure 1 may be implemented to provide intervention therapy for atrial fibrillation of high disorganization (type 2).

The process first begins by starting the second timer 62 in accordance with step 120. Next, in step 122, the third timer 63 is started. The second timer 62 times a pre-set time period of, for example, one hour, whereas the third timer 63 times a time period which is much shorter in length than the pre-set time period. The time period timed by the third timer 63 may be, for example, five minutes.

When the third timer times out as determined in step 124, the atrial arrhythmia detector 64 is once again activated in step 126. The atrial arrhythmia detector first determines in step 128 if the atria are still experiencing an arrhythmic episode. If the atria have self-reverted to normal sinus rhythm, the process then proceeds to step 130 by resetting the second timer 62, and then proceeds to step 132 to re-set the third timer 63. Once the third timer 63 is re-set in step 132, the intervention therapy is completed.

If, in step 128, it is determined that the atria are still in an arrhythmic episode, the atrial arrhythmia detector 64 will first determine if the atria are in atrial flutter in accordance with step 134, as previously described. If the atrial arrhythmia has self-reverted to atrial flutter, the process then proceeds to step 136 to provide therapy corresponding to atrial flutter which includes either overdrive pacing or low energy cardioversion of the atria. Once the intervention therapy is completed in accordance with step 136, steps 130 and 132 are repeated, as previously described, and the intervention therapy is completed.

If, in step 134, it is determined that the atria are not in atrial flutter, the process then proceeds to step 138 to determine if the type 2 atrial fibrillation has transitioned to the more organized type 1 atrial fibrillation. If the atria have transitioned to the type 1 atrial fibrillation, the process then proceeds to step 140 to apply the therapy corresponding to the type 1 atrial fibrillation, which includes the application of cardioverting or defibrillating electrical energy to the atria at an energy level of between .5 joules and 2 joules, for example. Once the therapy is completed in accordance with step 140, steps 130 and 132 are repeated, as previously described, and the therapy is completed.

If the atria have not transitioned to the more organized type 1 atrial fibrillation as determined in step 138, the process then proceeds to step 142 to determine if the second timer 62 has timed out. If the second timer has not timed out, the third timer 63 is then re-set in step 144 and the process returns to start the third timer 63 at step 122. However, if the second timer 62 has timed out, as determined in step 142, the process then proceeds to step 146 to provide defibrillating energy to the atria at a relatively high energy level to defibrillate or cardiovert the atria. In providing the intervention therapy of step 146, an energy level of greater than 2 joules and, preferably, on the order of 3 joules may be utilized for cardioverting the atria. Although not illustrated in Figure 3, it may be preferable to reconfirm the type 2 atrial fibrillation prior to performing step 146. When the intervention therapy is completed in accordance with step 146, steps 130 and 132 are repeated, as previously described, and the therapy is completed.

As a result, as can be seen from Figure 3, if it is determined that the atria are in the type 2 atrial fibrillation, which is atrial fibrillation of high disorganization requiring a therapy of relatively high energy cardioversion, the application of the cardioverting energy is delayed for a pre-set period of time of, for example, one hour to permit the atria to transition to a more organized form of atrial fibrillation, requiring lesser energy to successfully cardiovert the arrhythmic episode. The atrial activity is examined every five minutes, for example, during the pre-set time, to determine if the atria have self-reverted to a more organized form of atrial fibrillation. However, if at the end of the pre-set time of, for example, one hour, the atria have not self-reverted to a more organized form of atrial fibrillation, the atrial cardiovertor/defibrillator 30 will then provide atrial fibrillation therapy at the relatively high energy.

While in accordance with this preferred embodiment the degree of organization or disorganization of the atrial activity is determined by atrial cardiac cycle length alone, atrial cardiac cycle length variability may also be used in combination therewith for classifying the type of atrial arrhythmic episode. If such variability is employed, the compare stage 68 may compare each determined atrial cardiac cycle length to the average cycle length. The maximum difference therebetween may then be used as the degree of variability for further defining the atrial arrhythmia type. The relative degree of organization/disorganization may also be determined through the use of correlation functions applied, for example, to the atrial activity sensed at different areas of the atria. Such correlation functions are well known in the art.

In addition, although real time processing of the atrial activity to determine the atrial cardiac cycle lengths is contemplated by this preferred embodiment, it will be appreciated by those skilled in the art that such determinations may be made from data stored in memory during a data acquisition period prior to the atrial arrhythmia detector being activated for operating on the stored data to determine the atrial cardiac cycle lengths, the average cycle length, and the maximum variance between the cycle lengths and the average cycle length. Hence, while a particular embodiment of the present invention has been shown and described, modifications may be made and it is therefore intended in the appended claims to cover all such changes and modifications which fall within the true spirit and scope of the invention.

Claims

1. An atrial cardiovertor/defibrillator including a sensor for sensing activity of at least one of the atria of a heart to provide an electrogram signal, the atrial cardiovertor/defibrillator characterized by a criteria provider (70) for providing a respective different criteria for each of different types of atrial arrhythmia, a therapy provider (32) for providing a corresponding therapy to the heart for each of said different types of atrial arrhythmia, and an atrial arrhythmia classifier (64) responsive to the electrogram signal and the criteria provider for identifying one of the types of atrial arrhythmia and causing the therapy provider to provide the therapy to the heart corresponding to the identified one of the types of atrial arrhythmia.

2. The atrial cardiovertor/defibrillator of claim 1 further characterized in that the respective different criteria include a first criteria (76) for atrial flutter, a second criteria (78) for atrial fibrillation of intermediate organization, and a third criteria (80) for atrial fibrillation of high disorganization.

3. The atrial cardiovertor/defibrillator of claims 1 or 2 further characterized in that the therapy provider includes an atrial pacer (92) and an atrial cardiovertor (90).

4. The atrial cardiovertor/defibrillator of claims 1, 2 or 3 further characterized in that the atrial arrhythmia classifier causes the atrial pacer to pace the atria upon identifying atrial flutter.

5. The atrial cardiovertor/defibrillator of claims 1, 2 or 3 further characterized in that the atrial arrhythmia classifier causes the atrial cardiovertor to apply car-

dioverting electrical energy to the atria at a low energy level upon identifying atrial flutter.

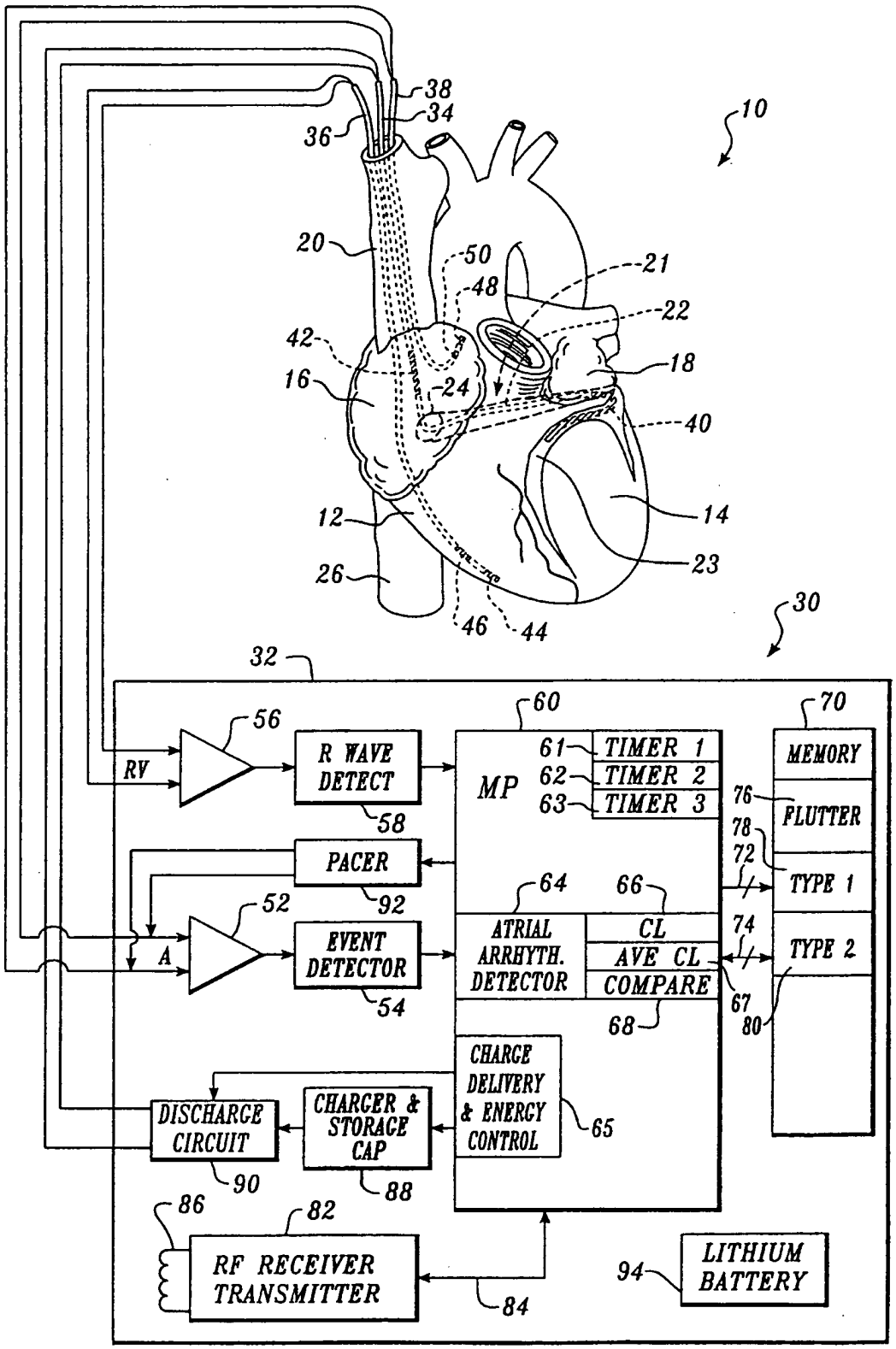
6. The atrial cardiovertor/defibrillator of claims 1, 2, 3, 4 or 5 further characterized in that the atrial arrhythmia classifier causes the cardiovertor to apply cardioverting electrical energy to the atria at an intermediate energy level upon identifying atrial fibrillation of intermediate disorganization.

7. The atrial cardiovertor/defibrillator of claims 1, 2, 3, 4, 5 or 6 further characterized in that the classifier causes the cardiovertor to apply cardioverting electrical energy to the atria at a high energy level upon identifying atrial fibrillation of high disorganization, the high energy level being greater in energy than said intermediate energy level.

8. The atrial cardiovertor/defibrillator of claims 1, 2, 3, 4, 5, 6 or 7 further characterized by a stage (66) for determining atrial cardiac cycle length and wherein the respective different criteria are based upon atrial cardiac cycle length.

9. The atrial cardiovertor/defibrillator of claims 1, 2, 3, 4, 5, 6, 7 or 8 further characterized by a second stage (68) for determining atrial cardiac cycle length variability and the respective different criteria being further based upon atrial cardiac cycle length variability.

10. The atrial cardiovertor/defibrillator of claim 7 further characterized by a timer 62 for causing the cardiovertor to delay the application of the high energy level cardioverting energy for a pre-set time period.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70
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RV
MP
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62 TIMER 2
63 TIMER 3
MEMORY
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FLUTTER
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PACER
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TYPE 2
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DISCHARGE CIRCUIT
CHARGER & STORAGE CAP
90
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86
82
RF RECEIVER TRANSMITTER
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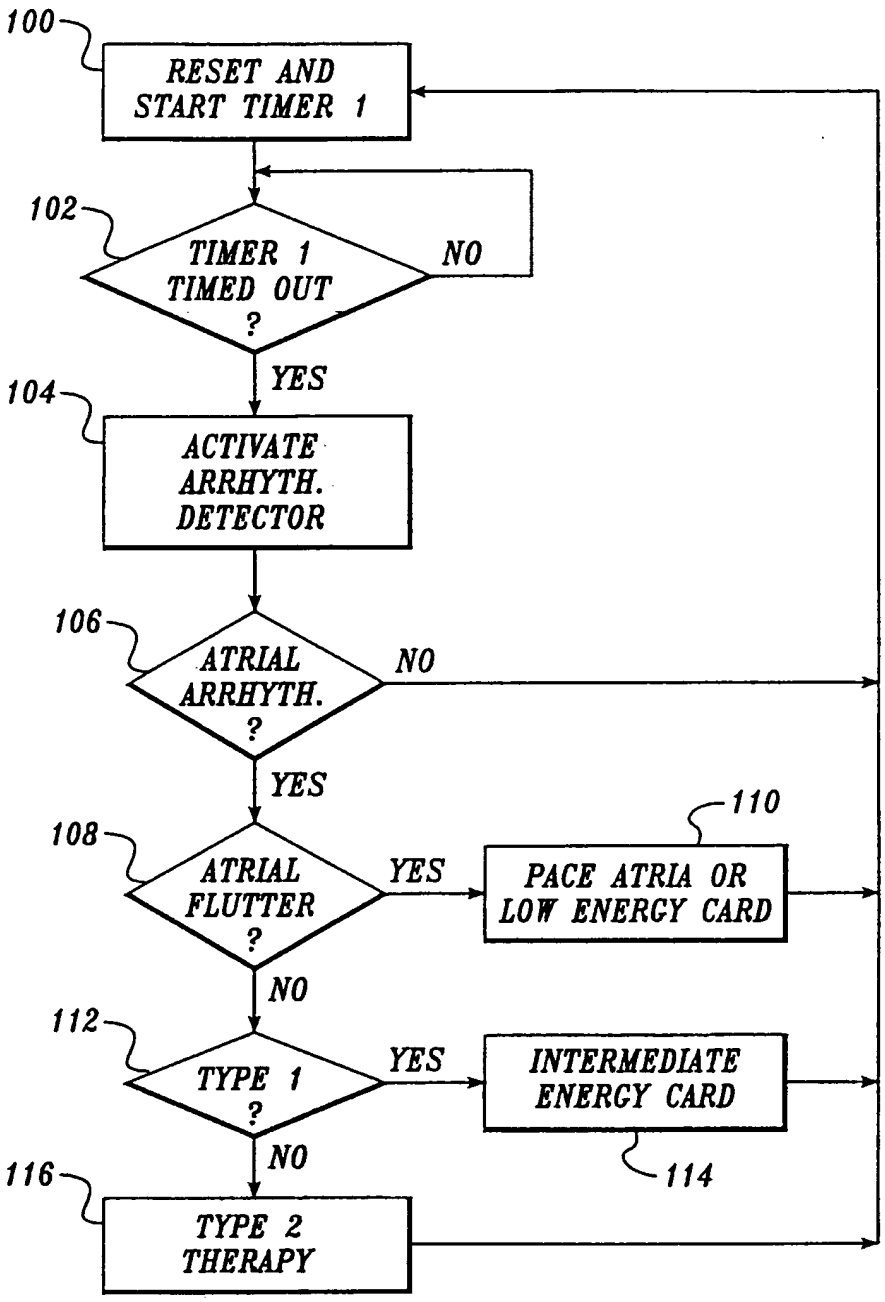
94
LITHIUM BATTERY


100
RESET AND START TIMER 1
102
TIMER 1 TIMED OUT ?
NO
YES
104
ACTIVATE ARRHYTH. DETECTOR
106
ATRIAL ARRHYTH. ?
NO
YES
108
ATRIAL FLUTTER ?
YES
110
PACE ATRIA OR LOW ENERGY CARD
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112
TYPE 1 ?
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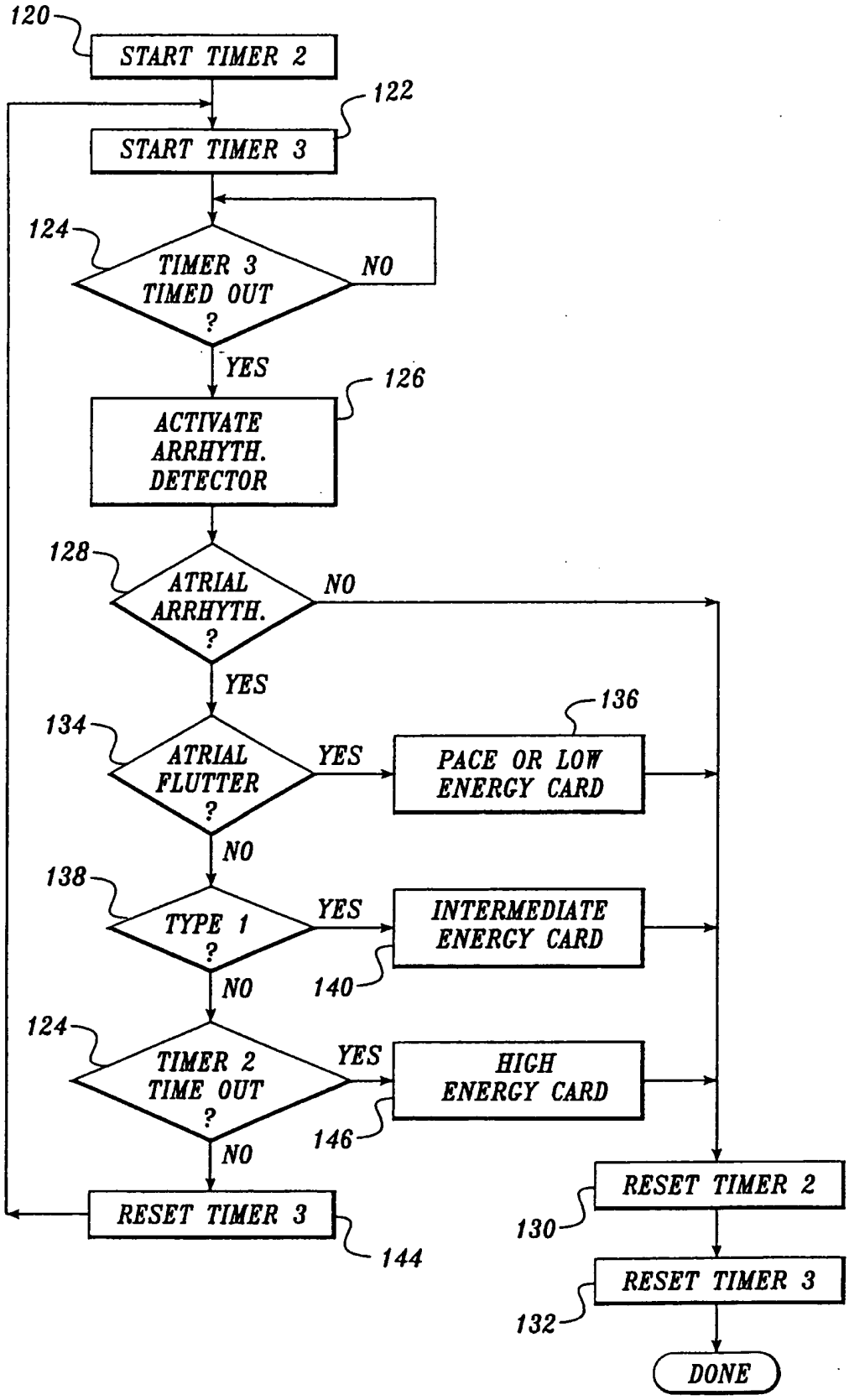
INTERMEDIATE ENERGY CARD
114
NO
116
TYPE 2 THERAPY

FIG. 2.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YES
136
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ATRIAL FLUTTER ?
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PACE OR LOW ENERGY CARD
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TYPE 1 ?
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140
NO
124
TIMER 2 TIME OUT ?
YES
HIGH ENERGY CARD
146
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RESET TIMER 2
130
RESET TIMER 3
132
DONE